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Eighth day of September 2003

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A RAINWATER TANK AND MAINS WATER SUPPLY CROSS CONNECTION SYSTEM

1/ FIELD OF THE INVENTION

The invention relates to a system for gathering and supplying roof water for water supply whilst maintaining the ability to use water supplied from another source such as a town water supply main. The system described in the invention provides a quick and automatic transition between the roof water and mains water supplies.

2/ RELATED ART AND OTHER CONSIDERATIONS

Many buildings in country areas rely on water piped from the roof into a tank for their water supply. The water is typically gathered via gutters and delivered via various optional filtration systems into a tank. Water is drawn from the tank to meet demand by a pump which supplies the water at pressure to the building's water reticulation system. This technology is well established.

In most urban areas the water supply is met by a mains system which delivers water to various buildings. This water is generally chemically treated and filtered. The water supply and reticulation authorities usually place stringent requirements that water from any source other than theirs cannot enter the mains system.

In most urban situations rainwater is shed from roofs to guttering and delivered into stormwater drains. Problems of urban flooding are frequently caused downstream of urban developments because of the higher volume of runoff and increased runoff rate in an urban environment compared to a natural one. Coping with this increased runoff requires costly and undesirable improved drainage.

In many urban situations water supplies are limited by either water storage limitations or considerations of reticulation.

A partial solution to the flooding and water shortage problems frequently associated with urban development is to store and utilise the water from roofs for water supply. The storage of the water will ameliorate flooding problems downstream whilst the use of the water will reduce demand on water supply.

For rainwater to be utilised in the urban situation where the populace is accustomed to mains water requires it to be delivered in a clean form and with minimal inconvenience. In the situation where rainwater may be used part of the time and mains water at other times then the transition between the two should be automatic and achieved with negligible disruption.

The water system should also meet normal requirements to ensure that tank water does not enter the mains.

3/ SUMMARY OF THE INVENTION

The essence of the invention is a logic and switching system to permit the use of stored rainwater when it is available and the use of mains water at other times or at times when electrical power is not available to drive a pump.

The system involves guttering to gather rainwater. The water is then coarsely screened to remove leaves and debris. The initial runoff (the first flush) from the roof is then sent to waste so as to effect a washing of the roof before water is sent to the tank via a finer screen.

The rainwater tank contains a water level sensor which is preferably a two level sensor. The sensor provides its output to a controller.

The water from the tank is delivered to a pump which pumps water out though a non return valve into the building via a coarse filter. The water line is buffered by an hydraulic accumulator and monitored by a pressure sensor or switch. If the switch is used it is of a kind that has some hysteresis in its switching behaviour, so that it switches on at a lower pressure than it switches off. The pressure switch/sensor provides its output to the controller.

The output line of the pump is connected to a servo operated 3 port valve which may be of a variety of forms including shuttle or ball valves. This valve is electrically driven to switch between mains water and tank water supply. Its switched position is governed by the controller. Its position is sensed by a location sensing device. Such devices include micro switches, light based, or magnetic field based detectors.

A preferred form of servo valve is a shuttle valve which can be moved between positions by a lower torque motor gearbox combination than can ball valves. This movement is achieved by connecting a lead screw to the output of the motor gearbox and running this in a thread within the shuttle shaft of the shuttle valve. This arrangement is cost effective to build.

The mains water supply is provided from the water main via non return valves as required by local regulations and an optional pressure regulator to the alternative inlet port of the servo operated valve.

The water level detection may be achieved by a variety of detectors which may include float switches, ultrasonic methods, capacitance meters and other devices. A preferred device is one in which a magnet is placed in a float and is used to operate reed switches or provide a signal to a magnetic field sensor, preferably a hall effect device. In

the latter, the output of the hall effect sensor is either directly measured or compared through two comparitors with preset voltage levels to provide a two level switch output.

The controller takes inputs from the water level sensor, the mains electrical power, water pressure at the accumulator, servo valve position and can additionally include battery voltage, temperature and a manual override switch which has the option of auto, tank or mains operation.

The controller controls the operation of the servo valve and the pump. It may also control the charging and discharging of the battery to suit temperature and battery requirements. The controller also has several alarm functions.

Several forms of control logic may be adopted. A preferred logic is described below.

Water is considered to be in the tank provided that:

a) There is water above the lower sensing level

b) If the water level has been drawn below the lower sensing level then water is not considered to be available again until the water level has risen to be above the upper sensing level.

The two level sensor provides an amount of hysteresis that prevents the pump and valve from oscillating due to slight variations in water level or variations in electrical output from the water level sensor.

The valve position is determined by the logic:

c) If the override switch is either mains or tank then this override should take precedence over automatic operation.

In automatic mode the logic is:
If there is water in the tank and power is available to drive the pump then the valve should be set to take water from the pump. If it is already in this position then there is no need for change, if however the valve is in the position for mains water supply then its position should be changed. In the event that the pump does not generate water pressure (see d below) then the valve is set to mains supply mode. If the valve is stuck between positions or does not move then an alarm is raised by the controller.

The pump operation is determined by the logic:

d) If the valve is set in the position to take water from the pump and the pressure sensor/switch detects low pressure then the pump should be on. If however the pressure does not rise within a pre-set period then the pump will be assumed not to have primed and will be turned off and an alarm turned on by

the controller.

Some additional control logic may be adopted for system protection. These may include:

Turning off the battery charging function if the temperature is high.

A deep discharge cycle to protect the system batteries. In this case the valve would be moved to mains water operation whilst the batteries are fully discharged and charged. Such a process would suit the use of nickel cadmium batteries.

Moving the valve to mains water operation in the event that battery charge is low.

4/ SHORT DESCRIPTION OF THE DRAWINGS

Figure 1 shows the elements of the total system

Figure 2 shows a water level detector employing a magnet in a float and a hall effect magnetic field sensor.

Figure 3 shows the output from the hall effect sensor with water level

Figure 4 shows the shuttle valve, servo motor/gearbox and micro switches to detect shuttle position.

5/ DESCRIPTION OF THE DRAWINGS

Figure 1.

Water may come either from the mains water supply (1) or from rain water which falls on the roof (24). In the case of mains water it would normally be supplied into the building's water supply pipe via a non return valve (2) which is installed to ensure no stray water enters the mains supply system. A regulator (3) may sometimes be installed in the water supply pipe line so as to control the incoming water pressure. The water then proceeds to inlet port (4) in the servo valve (5) and if the valve is so actuated by the servo mechanism (26) that the outlet port (6) is connected to the inlet port (4) water from the mains water supply may be supplied to the building.

The rain which falls on the roof (24) travels to the gutter (23) and into the gutter discharge pipe (22) across a coarse particulate matter separator (21) shown here in the form of a sieve bend which discharges coarse debris such as leaves (20) whilst permitting the water to pass into a device (19) that collects and discharges the first run-off from the roof and

with it any pollutants that have gathered on the roof. The device shown in (19) collects the first flush of water and pollutants before flow may proceed through the overflow (18) to the finer mesh (17) in the roof of the tank (16) which covers the tank (15). Water may be drawn out of the tank via the conduit (13) to the intake of the pump (11). The pump discharges water through the optional coarse filter (12) and non return valve (10). The position of these may be reversed. The water pressure is then sensed by a pressure sensor or switch (9) and is preferably buffered by the hydraulic accumulator (8) before entering the servo valve (5) through port (7). If the servo valve (5) is so actuated by the servo mechanism (26) that the port (7) is connected to the outlet port (6) then water from the tank is be conveyed to the building's reticulation system.

The controller circuit (25) takes electricity from a mains source (21) and uses it to charge an internal battery. The controller also detects the presence of mains power and water level via the level detector (14). It also receives an input from the pressure sensor/switch (9) and the servo valve's (5) position sensing mechanism located in the servo control mechanism (26). The controller (25) switches battery power to the servo control mechanism (26) to change the positions of the servo valve (5).

Figure 2.

This shows the form of a water level sensor which utilises a float (1) body of non magnetic material housing a magnet (2). The float (1) is contained in an outer tube of non magnetic material (3) and is restrained to a limited vertical movement by stops (7) and (8). The movement of the float is detected by a hall effect sensor (6) which is attached to the cable (9). The hall effect sensor (6) and cable (9) are protected from immersion. In the figure this as achieved by a sealant (5) and glue lined heat shrink (4).

Figure 3.

This shows the output of the hall effect sensor with output voltage on the lower axis and water level on the vertical axis. The voltage at point (1) is that which exists when the float is fully up against the upper movement stop. The voltage at point (2) is the upper water level threshold voltage. The voltage at point (3) is the lower level threshold voltage and the voltage at (4) is the output voltage of the hall sensor when the float is restrained by the lower stop. The voltage to water level relationship may be reversed by turning the magnet end for end.

Figure 4.

This shows the shuttle valve form of the servo valve. The body of the valve (1) contains ports (4), (6) and (7). The shuttle contains four seals (3). The shuttle (2) is shown in the figure at its leftmost position. In this case the port (4) is connected to port (6) for through flow. If the shuttle is at its rightmost position the port (7) will be connected for through flow to port (6). The lead screw (10) engages in a thread (9) within the shuttle (2). The rotation of the shuttle is prevented by the spigot (8) which slides within a longitudinal groove within the shuttle body (1) and is screwed into the shuttle (2). The lead screw is rotated by the motor (12) and gearbox (11) combination. When the lead screw is rotated the shuttle (2) moves linearly. The position of the shuttle is detected by the detectors (5) which are in this case micro-switches. Thus by powering the motor (12) the shuttle (2) can be moved to change connection between ports.

The behaviour of the valve shown is one of break connection and then make new connection. This type of connection means that direct flow between inlet ports cannot occur but means that there is a brief interruption to flow during switching. The shuttle can be arranged differently so that a make and break type connection occurs and no interruption to flow will occur. In this case it would be possible to have some communication directly between the inlet ports (7) and (4).

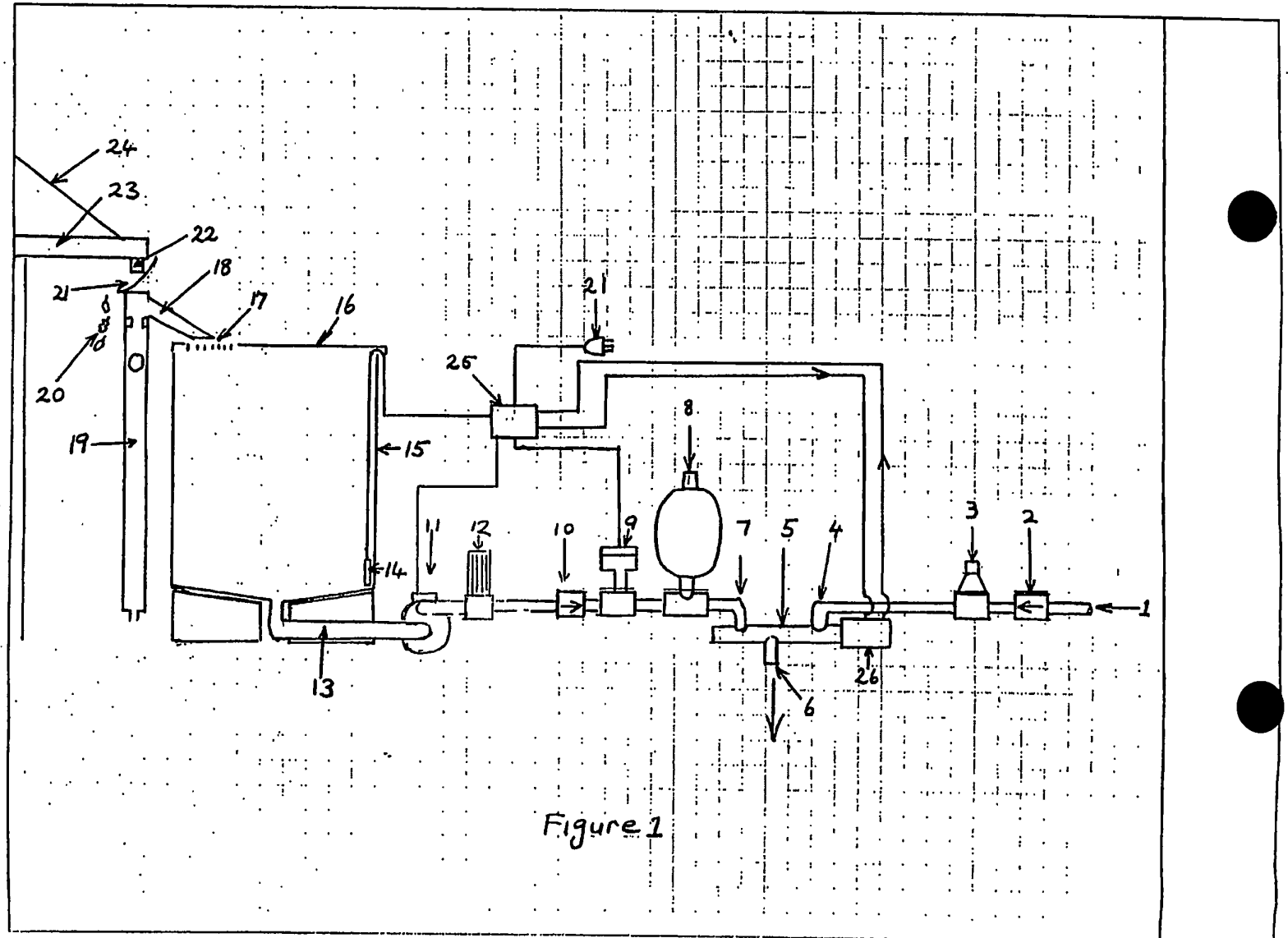

Figure 1

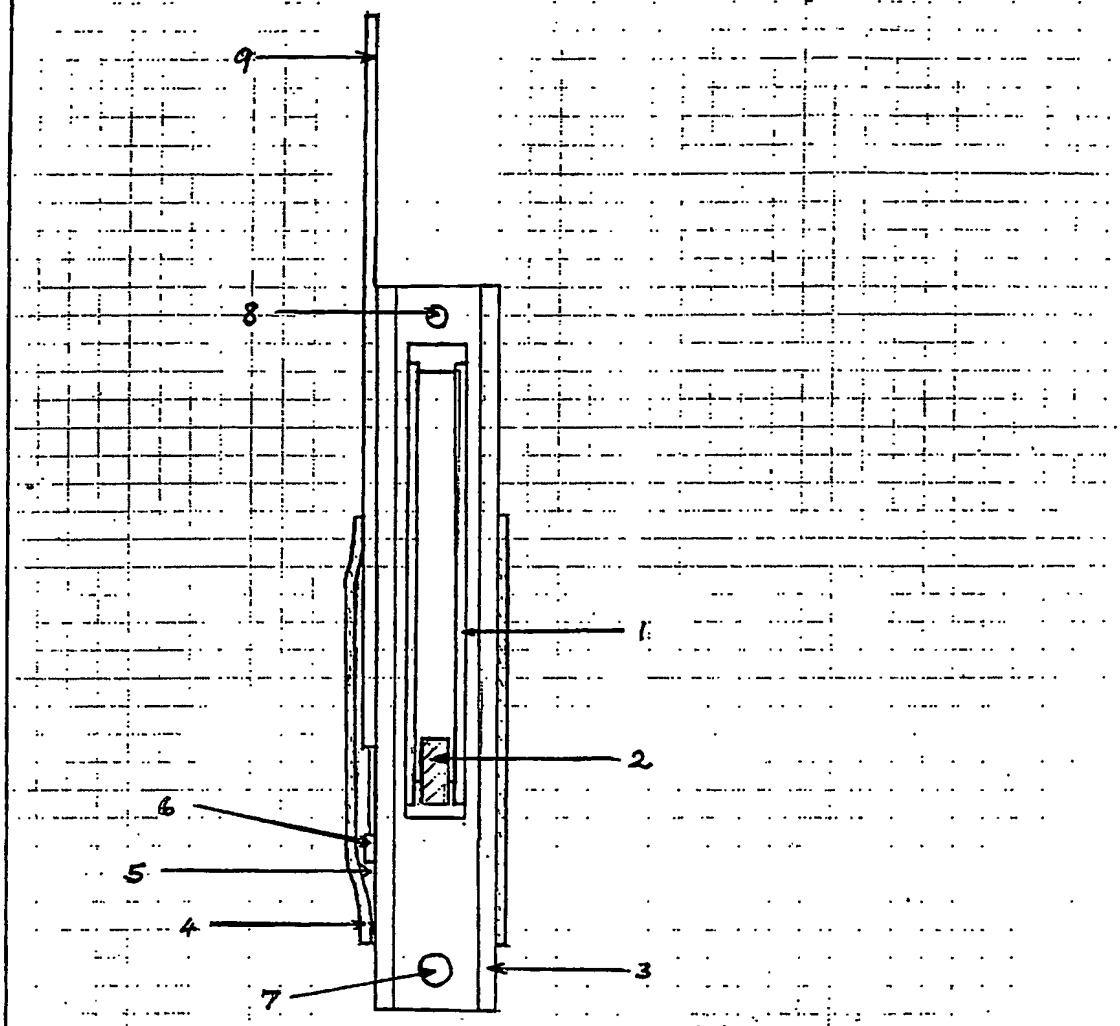

Figure 2

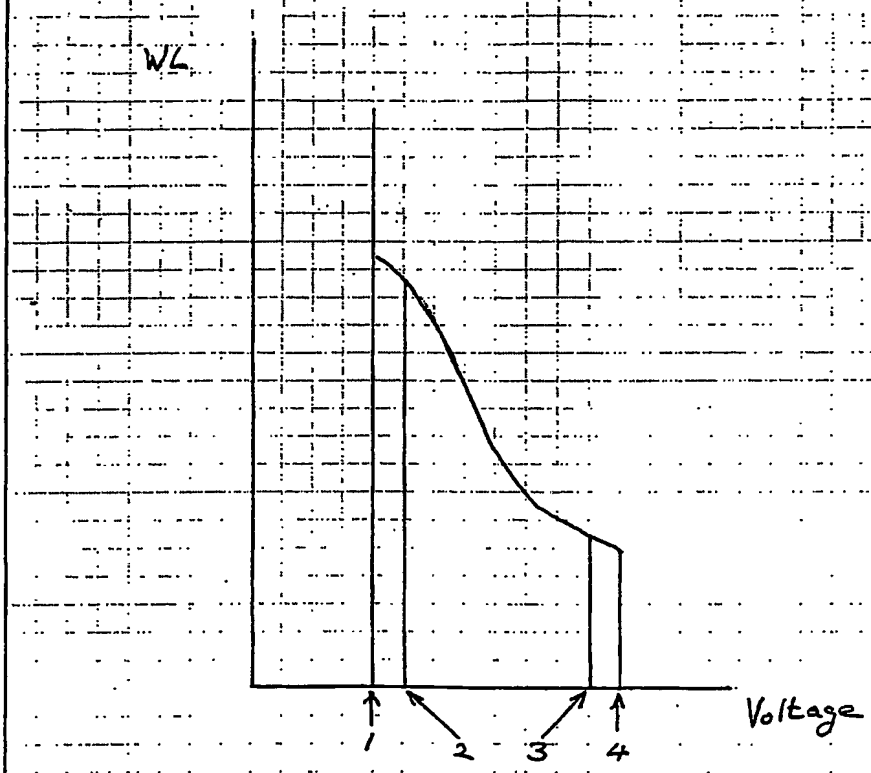

Figure 3

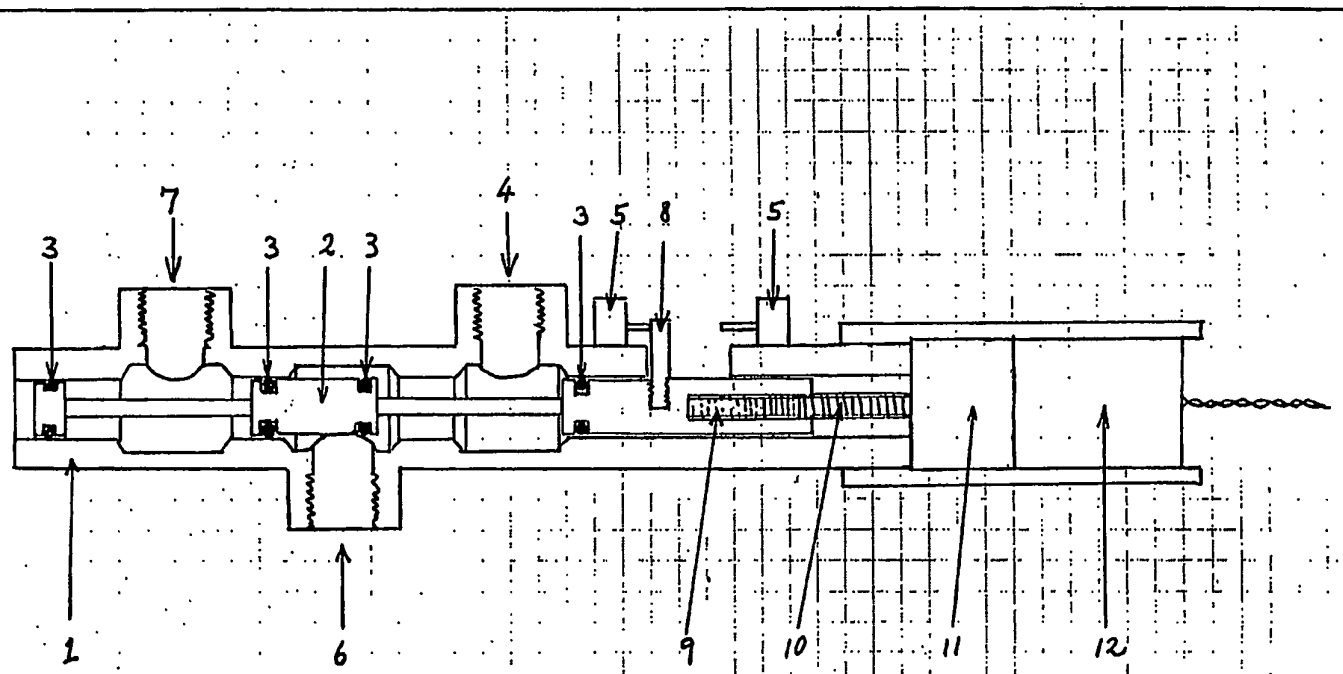

Figure 4.

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